



## Product-Service System (PSS) design: using Design Thinking and Business Analytics to improve PSS design

Jonatas Ost Scherer<sup>a,\*</sup>, Ana Paula Kloeckner<sup>a</sup>, Jose Luis Duarte Ribeiro<sup>a</sup>, Giuditta Pezzotta<sup>b</sup>,  
Fabiana Pirola<sup>b</sup>

*a) PPGEP- Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil*

*b) CELS – Dept. of Engineering, University of Bergamo, Bergamo, Italia*

\* Corresponding author. Tel.: 00 55 51 96956588. E-mail address: jscherer@producao.ufrgs.br

### Abstract

Companies searching for new ways to be competitive in dynamic markets are integrating product and service to better fulfill customer demands and improve sales. A well designed and efficiently developed Product-Service System (PSS) is a solid alternative to achieve this goal. The PSS design should search for new ways to add value for both company and customers. The PSS design model may help the company to innovate, strengthen competitiveness and assure the desired profit. In this paper we propose a methodology that integrates Design Thinking (DT) and Business Analytics (BA) in the PSS design in a way to build a profitable and lasting PSS. Design Thinking is a human-centered and systematic approach to problem solving and is used in the model to deeply understand customer needs and satisfy their emotional requirements considering company's resources and constraints. BA is the capacity to aggregate, to analyze and to use data in a way to optimize the business results. The large quantity of information available from sensors, logs and other machine sources, associated with information and communication technologies (ICT) advances allow companies to collect and analyze a large quantity of data. Through the data analysis, companies may evaluate consumer behavior, sense changes in the market quickly and identify new opportunities to innovate. Furthermore, companies may use the data as a third layer to add value besides the product and service layers. The proposed model addresses a lack in the literature of PSS design and adds relevant information for companies designing or reconfiguring a PSS.

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### 1. Introduction

Current market characteristics are demanding agility and value creation from companies. To achieve these goals, companies are integrating product and service in their offers [53]. One strategy, known as Product Service System (PSS), corresponds to the integration of product and service to deliver the desired functionality and add value to the customer [51]. However, PSS implementation brings new challenges for companies [14], like the service paradox [17] for example.

A well-designed PSS is relevant for the success of the initiative. It must contemplate customer and company perspectives [43] and support the company innovativeness [2]. There is a lack of literature addressing PSS design regarding these topics. Furthermore, PSS offers can be unique, demanding from firms the capacity to design innovative PSS

[53].

This paper proposes a PSS design model addressing innovation and added value. Through a literature review the characteristics relevant for a PSS and the suitable approaches to create an innovative PSS were identified. Design Thinking (DT) and Business Analytics (BA) approaches were selected to enhance the PSS design model proposed.

This paper is structured as follows, in sections 2, 3 and 4 PSS, DT and BA characteristics are presented. Next, in Section 5, the model and recommended tools for its implementation are discussed. Section 6 concludes the paper and proposes further developments.

### 2. Product Service System (PSS)

A system is a collection of entities that interact, so it is

necessary to clarify the PSS elements to achieve a better understanding of such systems. According to [36] and [51], the PSS elements are product, service, supporting network and infrastructure. A recent literature review [10] identified entities (englobing Mont supporting network and infrastructure elements), life cycle and actors as PSS elements.

[17] points out the necessity of PSS offering understanding to effectively design the PSS. [50] [51] proposes that PSS can be classified in product, use or result oriented; which is the prevalent approach for business model definition [45]. [42] classify according to the nature of integration, ownership of product and the role of technology. While [17] classify PSS in terms of orientation (product, use or result oriented), focus (product or service) and nature of integration between customer and PS provider (transaction or relationship based).

Furthermore, there are some aspects that should be considered for an effective PSS design. PSS literature emphasizes features like customer interaction [25] [36] [44] [53], network partnering [36] [53], knowledge creation [20] [21] [32] [40] [47] [55], customer and type of market particularities [35] [45] [51] and integration of product and service in the PSS design [4] [10] [36] [39] [43] [57].

There are different models addressing PSS design [5] [11] [22] [32] [38] [39] [43] [57]. [51] verified three common stages in the PSS design models, namely, analysis; idea generation, selection, refinement and evaluation; and planning and preparing implementation. While [43] identified customer analysis; requirement analysis; PSS design; and PSS test and implementation as common stages in PSS design literature. Among these models, the most applied methods in PSS design are Analytic Network Process (ANP), Analytic Hierarchical Process (AHP), Service Blueprinting and FMEA [10]. Despite the innovation relevance for the business health, there is a lack in addressing this theme in PSS design models.

### 3.Design Thinking (DT)

Design Thinking is a human-centered and systematic problem-solving approach [9] [28] [30]. DT emphasizes the deeply understanding of customers in order to satisfy their emotional requirements as well. According to [9] [24], DT provides the reliability of the analytical thinking and the creativity of intuition thinking to match human needs considering the business constraints. DT translates observation in insights and insights in innovation through an exploratory, iterative and non-linear process [9] [23] [28].

One of the DT advantages is that through this process the company can innovate based on the perspective of the users and consequently maximize the user experience adding value to the product [24]. Furthermore, DT enables to link managers' perceptions, rational analysis, technical, cultural and commercial factors to boost value to the customer and market opportunities for the company [24].

There are different DT models [9] [48] HCD; [24] where it is possible to identify three common phases (Table 1), inspiration, ideation and implementation. According to [9], the DT process is best thought as a system of overlapping spaces rather than an orderly sequence of steps.

Table 1 – DT phases [9].

Phase	Definition
Inspiration	Is the problem or opportunity that motivates the search for solutions, gained through observation, empathy, and immersion in the user's context.
Ideation	Is the process of generating, developing and testing ideas, identifying patterns, defining opportunities and creating solutions.
Implementation	Is the path that leads to the market.

DT is successfully applied in product and service development, and in different kinds of markets (B2B, B2C and B2G). Examples of companies using DT are P&G, Pfizer, Intel and Nokia.

### 4.Business Analytics (BA)

Business Analytics (BA) is the process of patterns identification or mathematics decision models creation from a determined set of data allowing decision making based on data which add value to the company [1] [6] [13]. According to [1] [6] [8], this process of knowledge discovery based in data receives different names in the literature, like business analytics, data mining, data analysis, data science or knowledge discovery.

BA can be classified as descriptive, predictive or prescriptive in terms of objectives; quantitative, qualitative or hybrid regarding to the approach, and make use of structured, semi-structured and unstructured data [14] [19] [54]. Techniques like linear/non-linear regression, logistic regression, time-series model, optimization, clustering, factor analysis, principal component analysis (PCA), neural networks, support vector machines (SVM), Bayesian techniques and survival analysis are used in the BA process [29] [37].

The company can create value from different ways through BA [27] [29] [34]. For instance, it can be used to customer segmentation [7] [16] [34] or product performance evaluation [27] [29] [46]. Examples of companies that are aggregating BA to their PS offers are GE [2], The Michelin Group, Taleris and Daimler Car2Go [3].

### 5. Proposed PSS design model

According to the Schumpeterian economics firms compete through innovation and the ones innovating more efficiently will succeed. The Schumpeterian concepts are applicable for manufacturing and service industries as well [15].

An efficient PSS design should consider the customers and the company perspectives [43]. Furthermore, it should include some innovation steps to search for new ways to add value for both actors. There is a gap in PSS design model literature regarding innovation steps. So, to approach this gap the model

proposes the use of DT and BA tools in the PSS design.

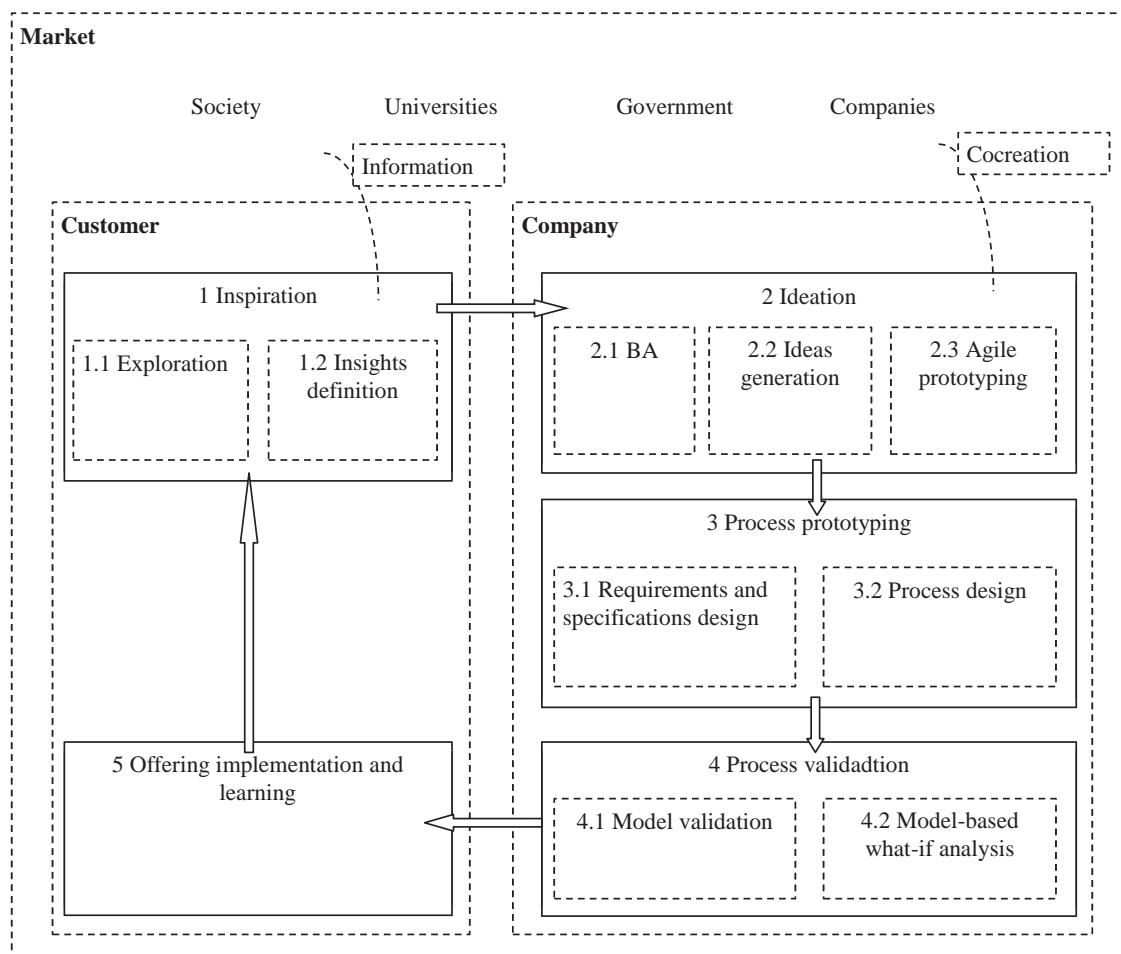
DT emphasizes a deep understanding of customer needs [9] [24]. To add value for the customers it is necessary to identify and understand customer needs. However, as pointed out by [18], companies should understand not only the articulated needs but also the unarticulated ones. Additionally, companies should be able to establish predictions not only from public data but also from his own or partners' sources [18]. BA is complementary to DT, through BA techniques firms can make use of ubiquitous presence of sensors to sense changes in customer behavior [40] adding relevant information for DT process. The proposed model is based on these premises and the PSS characteristics listed in the previous section (section 2.1). For validation, the model was discussed with specialists

in the PSS area.

The model construction is based in the SEEM model proposed by [43]. The SEEM model was chosen because it proposes a balance between the customer and company perspectives. Besides that, it allows to insert an innovation focus covering the value addition for customer and company.

The proposed model (Figure 1) has five phases, namely: i) inspiration, ii) ideation, iii) process prototyping, iv) process validation, and v) offering evaluation and learning. There is a group of tasks to be performed in each of these phases. The customer and company are inserted in the outer market block. Besides these two agents, this block also includes the society, universities, government and (other) companies.

Figure 1: proposed model



### 5.1. Inspiration

The PSS design starts with the inspiration phase. This phase aims to discover customer needs, articulated and unarticulated, in order to generate insights that lead to innovation [48] and consequently a profitable PSS.

One important aspect is that the company should not to

restrain the search for inspiration to its current customers. The company should look into the market to discover and evaluate potential opportunities.

There are two tasks to be performed in this phase, exploration and insights definition.

#### 5.1.1. Exploration

For better identification of customer needs, the current

reality that they are facing must be explored. A deep understanding of product usage, context and people interaction is mandatory to succeed in innovation and customer satisfaction [26] [30]. In this way, DT allows discovering the underlying requirements through close observation of people [24].

For the exploration task, the following tools are indicated:

- a. *Image Sorting*: a method used to find out peoples' associations and perceptions about particular topics, revealing the emotions, relationships and values they associate with other people, places and objects in a situation [26].
- b. *Extremes*: the identification of extreme users or behaviors to generate specific opportunities. This approach can generate a different view of that achieved through market research [31].
- c. *Five Human Factors*: a complete understanding of products and services user experience through the analysis of five factors: i) physical; ii) cognitive; iii) social; iv) cultural; and v) emotional [26].
- d. *Trends Matrix*: it summarizes how trends and forces impact business, people, society and policy [26].
- e. *Empathy*: it helps to develop a better understanding of the environment, behavior, concerns and aspirations [30] [31] [52].

#### 5.1.2. Insights definition

Adding, editing, synthesizing and condensing what have been learned in the exploration phase enables to discover and establish new perspectives, connections and patterns [31]. The insights give the directions for the development of innovative and profitable ideas [31]. It is important to differentiate insights from ideas. Idea is the solution generated from one or more insights [52]. To achieve these insights it is suggested to perform a brainstorming session making use of different tools, like trends matrix, convergence map, and offering-activity-culture map [26].

#### 5.2. Ideation

Following the process of inspiration, where the goal is to explore the problem and identify opportunities, there is the ideation phase. In this phase BA techniques are added to DT approach to generate PSS ideas.

Following [9], ideation includes ideas generation, development and agile prototyping tasks. According to the proposed model, during the ideation phase the company should consider exploration and exploitation strategies associated with co-creation [33] [44] [53] [56]. External agents could open a range of new opportunities for PSS delivery, like for example Taleris, a GE-Accenture joint venture [2].

##### 5.2.1. Business Analytics (BA)

ICT facilitates the collection of different types of data [32] but companies in general are not making use of them [40]. Through BA, companies can sense changes in customer behavior [40], identify patterns of product and service use [14], and identify customer segmentation [7] [16] [34].

Furthermore, the ubiquitous presence of sensors allows to add many information services to products. It is possible to predict performance and degradation [27] [34] and to create digital services for customers [2].

All of these possibilities enable to enrich the ideation process. Different techniques can be used in this task such as cluster analysis for customer segmentation [58].

Additionally, companies can identify opportunities to exploit data generation like a new revenue flow [40].

##### 5.2.2. Ideas generation

This task comprises the generation of new ideas based on the understanding of the problem. The ideas generation is the process of generating, developing and testing ideas, identifying patterns, defining opportunities and creating solutions. During this phase, the proposal will pass from concrete to abstract thinking - to identify issues and opportunities - and then return to the concrete thinking with the creation of solutions and prototypes.

Tools used in this task are:

- a. *Brainstorming*: the potential advantage of brainstorming is typically attributed to the possibility to use a structured environment to build on team members' ideas [48].
- b. *Design Concept*: convert ideas into concrete forms that are easier to understand, to discuss, to assess and to communicate [26] [30].
- c. *Napkin Pitch*: provides a simple and consistent format to summarize and communicate new concepts. It facilitates for the team the development of multiple concepts of innovation in parallel. [30].
- d. *Concept Generating Matrix*: takes two sets of important factors (i.e., different customer niches and needs) organizing them into a two-dimensional matrix to help exploring concepts at their intersections [26].

##### 5.2.3. Agile prototyping

At the end of the idea generation task there will be a large number of ideas which should be assessed and selected to the agile prototyping task. Prototyping is the process by which novel ideas are developed into a preliminary model, enabling evaluation of a given approach as well as further ideation. Through the process of rapid experiment, feedback and improvement, companies can achieve high added value with low investment [24]. Besides it allows effective feedbacks for timely improvements.

The suggested tools for this task are:

- a. *Solution Storyboard*: a set of drawings arranged in sequence, representing scenes of a story, describing how all the concept parts work together and how the solution will add value [26] [30] [49] [52].
- b. *Solution Prototyping*: a method in which users are observed performing the activities in a prototype of the proposed solutions. They can be of two types: i) appearance prototype; and ii) performance prototype [26] [30].
- c. *Service Prototype*: a simulation of a service experience. This simulation can range from being informal "role-

play” style conversations, to more detailed full scale recreations involving active user-participation and physical touch points.

### 5.3. Process prototyping

Similar to the SEEM methodology [43], the objective of this phase is to build the final prototype of the solution which will be included in the service portfolio. How [43] pointed out, there are two tasks to be realized: (i) requirements and specification design, and (ii) process design.

For the first task, [43] proposes to use the *Service Requirement Tree (SRT)* to provide a detailed evaluation of the ideas previously identified in relation with customer needs and with the PS provider resources.

The Service Blueprinting technique is recommended for the process design task [43]. With the blueprinting the detailed design of the service delivery process is defined and according to [43] this technique is complementary to SRT to verify the PS requirements accomplishment.

### 5.4. Process validation

Following the SEEM methodology, this phase is necessary to validate and assess the service delivery process previously designed and the related performance and to define the appropriate resources configuration. For validation purpose, [43] reinforce the use of simulation techniques..

### 5.5. Offering implementation and learning

The last phase of the proposed PSS design corresponds to the implementation of the PSS designed in the company portfolio. The company should provide the structure and resources necessary for the PS offering.

Furthermore, the company should learn from the PS delivered. This is associated with the path dependency [12] and path creation [41] concepts. Learning during the PSS operation is important to assure the quality of the service [47], and for continuous improvement and design of new PSS [21] [55].

## 6. Conclusion and further development

Driven by the need to be more competitive companies are implementing PSS. In this paper, we identified in the literature the PSS important characteristics and proposed a model to PSS design in an effective way. Customer and PS provider are accounted without ignore other stakeholders in the search for the appropriate PSS configuration.

The application of DT and BA tools in the model enables a deep understanding of customers' needs besides to bring new ways to develop innovative and profitable. Through DT, articulated and unarticulated customer needs are translated into PSS requirements. ICT advances enable to easily acquire data which can be used via BA to sense market changes, identify patterns and segment customer for a more effective PSS design.

The proposed model was validated by specialist but further development is necessary. The applicability of the model in

different sizes and kinds of industries, and the necessary resources and company staff competences demand complementary research.

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